1553 INTERFACE REQUIREMENTS DOCUMENT

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FOR

NPOESS

STRAWMAN REORGANIZATION

07/11/2002

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1 SCOPE

This document defines the functional requirements baseline for the 1553 interfaces between the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) spacecraft and instruments. The Spacecraft Contractor and the Instrument Provider shall each meet their respective interface requirements as defined in this document. The Unique Instrument Interface Documents (UIIDs) and the General Instrument Interface Document (GIID) are the contractually imposed documents that represent the agreement between the NPOESS spacecraft contractor and the Instrument contractor.

This document is intended to cover all requirements and information related to the usage of MIL-STD-1553B and CCSDS in combination for both telecommands and telemetry. The intent is to avoid having instrument contractors assuming the answers to any design decision. This document will be living to the extent that as questions from instrument contractors arise, the answers will be documented here.

Due to the usage of both MIL-STD-1553B and IEEE-1394a-2000 within a common system, this document has been constructed to reduce to complexity that might arise from having portions of the requirements that are common to both by repeated them appropriately within each bus specific interface requirement document.

The overall philosophy is that all instruments are required to support the requirements and options contained in MIL-STD-1553B Notice 2 as described within this document 100%. All exceptions will require specific waivers and are strongly discouraged. This includes software and hardware. The only exception to MIL-STD-1553B Notice 2 and its options is bit ordering. Bit ordering is reversed for compatibility to modern data processing systems including networks.

1.1 1553 Data Bus System Description

The NPOESS Spacecraft uses the MIL-STD-1553B data bus for communication between the following devices:

- Spacecraft Bus Controller
- Spacecraft Functions
- OMPS
- ATMS
- ERBS
- TSIS
- SESS (multiple interfaces)
- GPSOS
- SARSAT (TBD)
- ALT
- ADCS (TBD)

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- APS
- Special Instrument (TBD)

The 1553B bus uses a serial asynchronous command/response protocol at a fixed transmission rate of 1 Mbps. The spacecraft provides multiple MIL-STD-1553B buses sufficient to adequately accommodate the total required bandwidth plus margin.

Information passed over the 1553B bus includes ground commands, housekeeping data, science data, periodic time broadcasts, code/data uploads, and reset commands. Commanding of all 1553B RT nodes is performed via the 1553B data bus. Periodic data is transferred at a predefined rate while aperiodic data (e.g., ground commands) is generated in a non-deterministic manner and is therefore transferred whenever required.

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2 APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, shall form a part of this document to the extent specified herein. When no issue is specified, the latest version of the document shall apply. In the event of conflict between the documents listed here and the GIID, the contents of the GIID shall be considered superseding.

	General Instrument Interface Document (GIID)
	Deleted: . 1394 Interface Requirement Document (IRD)
MIL-STD-1553B	Notice 2, Military Standard Digital Time Division Command/Response Multiplex Data Bus
CCSDS 301.0-B-2	Consultative Committee for Space Data Systems (CCSDS) Recommendation for Time Code Formats, Blue Book, April 1990
CCSDS 701.0-B-2	Advanced Orbiting Systems, Networks And Data Links, Nov 92

3 1553 CONFIGURATION REQUIREMENTS

3.1 Bus Type

The 1553 bus shall be dual standby redundant and fully comply with the requirements of MIL-STD-1553B, Notice 2 (Applicable Document 2.6), all sections.

Note: Additional requirements are specified wherever necessary to select MIL-STD-1553B options and to eliminate ambiguities.

3.2 Bus Topology

The basic topology for the 1553B bus shall be as shown in Figure 3-1. This topology provides full data bus media redundancy by using redundant cables and data bus couplers.

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3.3 Configuration

All instruments shall be configured as remote terminals (RT) under all modes of operation.

All 1553B nodes shall be compliant with MIL-STD-1553B, Notice 2 and shall use the transformer coupling option for the bus connection.

The spacecraft shall provide the Bus Controller (BC) and possibly one or more remote terminals (RT) to send data to and collect data from the instrument.

3.3.1 Electrical Interface

Each electrical interface to the 1553 bus shall comply with the requirements of MIL-STD-1553B.

3.3.2 Number of Functionally Distinct Instrument Remote Terminals

Each instrument using the 1553 data bus shall have one and only one dual redundant RT interface coupled to the data bus.

3.3.3 Transformer Isolation

Each RT shall be individually transformer coupled as shown in Figure 3-2 to both the primary and the redundant 1553 buses.

The interface design shall implement a long stub match system of transformers.

3.4 MIL-STD-1553B Fault Tolerance

No single failure in the 1553 bus electrical interface circuit on either the instrument side of the interface or the spacecraft bus side of the interface shall cause the instrument to lose the capability to communicate with both the primary and the redundant 1553 buses via each functionally distinct RT.

3.4.1 Instrument Unit Fault

A fault anywhere within the instrument or the data bus shall be precluded from propagating to redundant portions of the instrument or to the data bus.

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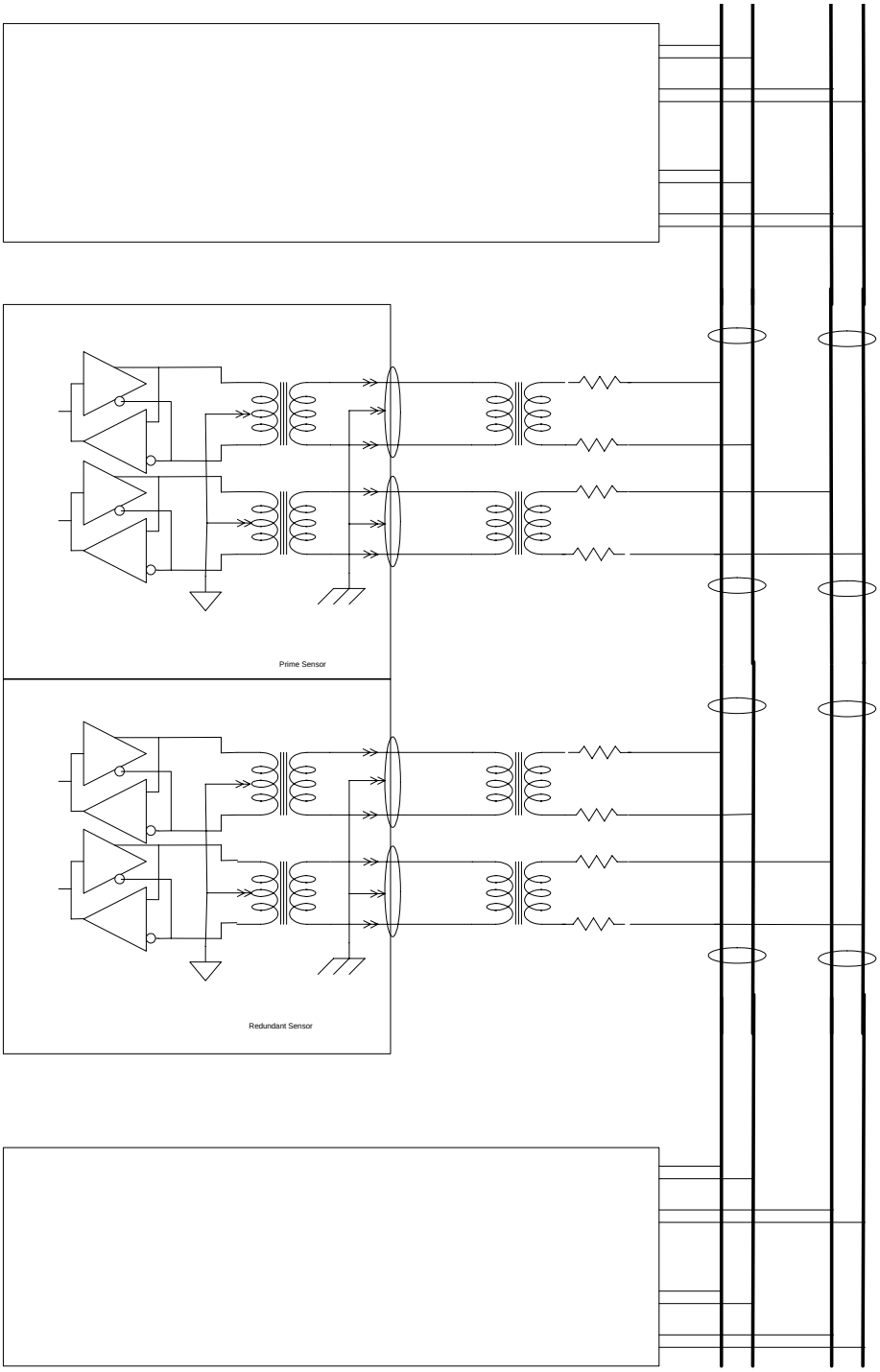

Figure 3-1 1553 System Topology

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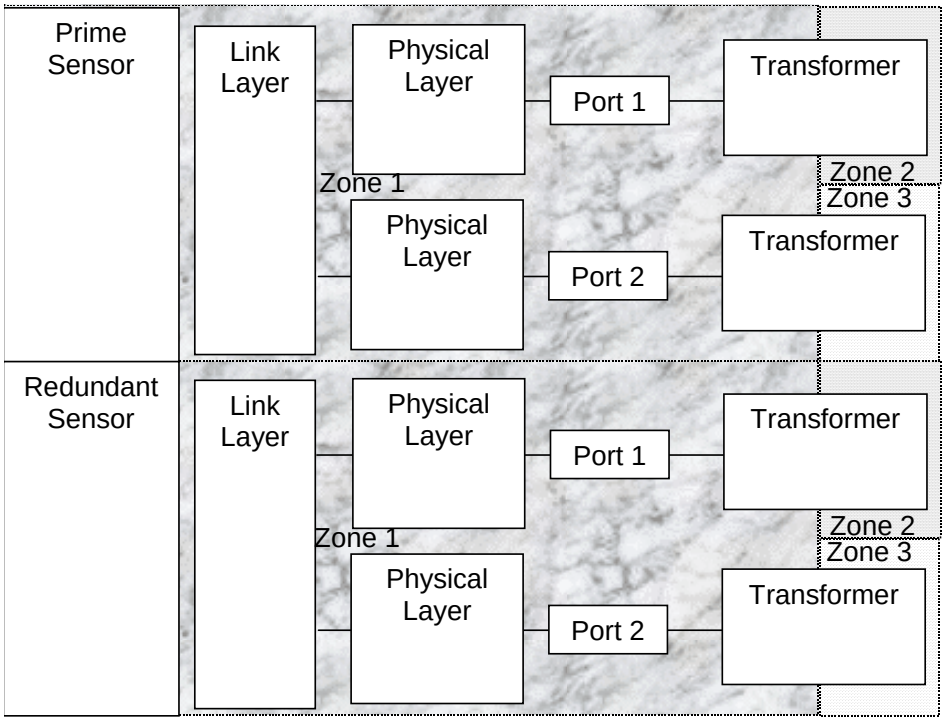

Figure 3-2 1553 Fault Isolation

3.5 Bus Functions

The 1553 bus shall communicate the following:

- a. Real time commands - commands from the ground or generated on-board
- Spacecraft stored commands - commands stored by the spacecraft for later execution
- Memory loads - memory loads, including instrument stored command tables from either the ground or the spacecraft. Memory loads will arrive as whole CCSDS Packets even when the load is segmented. .

  Ie:The spacecraft is receiving a memory load from the ground addressed to an instrument. As it receives whole packets the data is shipped to the instrument. At the limit of the link field-of-view a partial packet is received before loss-of-signal. That partial packet is not forwarded. The instrument must be able to wait for subsequent portions of the segmented block of data. While waiting for the next segment, other telecommands will be received by the instrument on separate APIDs.

- Ephemeris and time code data.

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b. Instrument to spacecraft transfers consisting of:

- Engineering data - support data required to meet specified science data processing performance
- Housekeeping - data related to instrument state of health
- Calibration data - data resulting from the instrument's calibration and alignment
- Mission science data - data as defined by the instrument related to observations
- Diagnostic data - data specifically generated to diagnose a suspected problem
- Dwell data - data produced by a commanded dwell mode to super-sample a specific subset of information
- Telemetry monitor data - minimum data set needed to be monitored by the spacecraft which require prescribed actions by the spacecraft.
- LEO&A data – reduced housekeeping data for Launch Early Orbit & Anomaly monitoring

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4 SERIAL-DIGITAL DATA FORMATTING

4.1 Bit Numbering

All multiple bit sequences shall count bits beginning with bit 0[a].

4.2 Octet Structure

All data shall be modulo based upon the smallest object, an Octet , comprised of eight (8) binary bits to be formatted as MSB (bit zero) first and shall be pictorially represented as shown in Table 4-1.

Table 4-1 Octet Representation

Bit Zero MSB	1	2	3	4	5	6	Bit Seven LSB

4.3 Digital Data Format

Data shall be in 2's complement with 1 being true. Exceptions shall be documented in the UIID.

4.4 Octet Numbering Convention and Nomenclature

The transmission order of bits within an Octet and the relative ordering of octets within a word shall be submitted for transmission 'Big Endian[b].

When applied to networking, this is called 'Network Byte Order'.

- Bit 0 of an N-bit$_{(\text{modulo 8bits})}$ value shall be the Most Significant Bit (MSB).
- Bit N-1 of an N-bit$_{(\text{modulo 8bits})}$ value shall be the least significant bit.

The octet containing bits 0-7 shall be transmitted first, followed by the next sequential octet until all octets are transmitted.

4.5 Bit Sequencing

For serial data, the most significant bit (MSB, i.e. bit zero) shall be sent first.

4.6 Data Segment Sequencing

For data segmentation, the segments shall be sent ordered most significant segment first

4.7 Spare Bits

All "spare" bits shall be permanently set to value "zero".

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[a] Bit Numbering convention is different than 1553 but compatible with data from the 1394 bus.

[b] Note also that 'Big Endian' byte ordering is NOT what some machines (notably the 80x86 class of machines) use internally.

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5 MIL-STD-1553B OPERATION

5.1 RT Addresses

Each RT and BC shall contain a fixed and unique physical address to differentiate the data on the data bus intended for its consumption.

5.2 RT Physical Address Assignment

Instrument RT physical address assignment shall be as listed in Table 5-1.

5.3 Physical Address Reassignment

The RT address shall be externally selectable without disassembly of the instrument.

Table 5-1 1553 Physical Addresses (TBR)

RT Unit	Address	RT Unit	Address
	00		16
ATMS	01		17
OMPS	02		18
ERBS	03		19
TSIS	04		20
GPSOS	05		21
ALT	06		22
ADCS	07		23
APS	08		24
Special Sensor	09		25
SARSAT	10		26
SESS	11		27
	12		28
	13		29
	14	Bus Monitor	30
	15	Broadcast 1553 Messages	31

5.4 RT Sub-address Assignment

Assignment of instrument RT receive sub-addresses and transmit sub-addresses shall be as tabulated in Table 5-2 and Table 5-3 respectively.

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Table 5-2 Instrument RT Receive Sub-address Assignment	
RT Receive Sub-address	**Data/Function**
00	Mode Code
01	Reserved
02	Reserved
03	Reserved
04	Reserved
05	Instrument Commands or Memory Loads
06	Instrument Commands or Memory Loads
07	Instrument Commands or Memory Loads
08	Instrument Commands or Memory Loads
09	Instrument Commands or Memory Loads
10	Instrument Commands or Memory Loads
11	Instrument Commands or Memory Loads
12	Instrument Commands or Memory Loads
13	Instrument Commands or Memory Loads
14	Instrument Commands or Memory Loads
15	Instrument Commands or Memory Loads
16	Instrument Commands or Memory Loads
17	Instrument Commands or Memory Loads
18	Instrument Commands or Memory Loads
19	Instrument Commands or Memory Loads
20	Instrument Commands or Memory Loads
21	Time Code Data
22	Time Code Data
23	Reserved
24	Reserved
25	Reserved
26	Reserved
27	Reserved
28	Instrument Reset Command
29	End of Data Transfer Cycle
30	Data Wrap Around
31	Mode Code

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Table 5-3 Instrument RT Transmit Sub-address Assignment	
RT Transmit Sub-address	**Data/Function**
00	Reserved
01	Reserved
02	Reserved
03	Reserved
04	Reserved
05	Data Packets
06	Data Packets
07	Data Packets
08	Data Packets
09	Data Packets
10	Data Packets
11	Data Packets
12	Data Packets
13	Data Packets
14	Data Packets
15	Data Packets
16	Data Packets
17	Data Packets
18	Data Packets
19	Data Packets
20	Data Packets
21	Reserved
22	Reserved
23	Reserved
24	Reserved
25	Reserved
26	Reserved
27	Reserved
28	Reserved
29	Data Readiness Indicator
30	Data Wrap Around
31	Reserved

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5.5 Mode Codes

The instrument RT shall be capable of supporting all 1553B mode codes in Table 5-4.

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Table 5-4 MIL-STD-1553B Mode Code Implementation Requirement			
Mode Code	**Function**	**Req'd**	**Implementation Requirement**
00000	Dynamic Bus Control	N	Ignored/not supported
00001	Synchronize	Y	Shall be implemented in hardware and nothing shall preclude later use by software as required by MIL-STD-1553B
00010	Transmit Status Word	Y	As required by MIL-STD-1553B
00011	Initiate Self Test	Y	Shall result in a status word per Table 5-5.
00100	Transmitter Shutdown	Y	As required by MIL-STD-1553B
00101	Override Transmitter Shutdown	Y	As required by MIL-STD-1553B
00110	Inhibit Terminal Flag Bit	Y	As required by MIL-STD-1553B
00111	Override Inhibit Terminal Flag Bit	Y	As required by MIL-STD-1553B
01000	Reset Remote Terminal	Y	Shall Reset the MIL-STD-1553B logic in RTs
01001	Reserved	N	Ignored
		N	
		N	
↓	↓	N	↓
01111	Reserved	N	Ignored
10000	Transmit Vector Word	N	Ignored
10001	Synchronize with data word	Y	Shall be implemented in hardware and nothing shall preclude later use by software as required by MIL-STD-1553B
10010	Transmit Last Command	Y	As required by MIL-STD-1553B
10011	Transmit BIT Word	N	Ignored

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Table 5-4 MIL-STD-1553B Mode Code Implementation Requirement			
Mode Code	**Function**	**Req'd**	**Implementation Requirement**
10100	Selected Transmitter Shutdown	N	As required by MIL-STD-1553B (BC to Single RT and BC to Multiple RT's)
10101	Override Selected Transmitter Shutdown	N	As required by MIL-STD-1553B (BC to Single RT and BC to Multiple RT's)
10110	Reserved	N	Ignored

5.6 Status Word

During the 1553 bus operation, the status bits in the status word transmitted by the instrument RT shall be implemented in accordance with Table 5-5.

Table 5-5 MIL-STD-1553B Status Word Implementation Requirement			
Status Bits	**Function**	**Req'd**	**Implementation Requirement**
1 – 3	Synch	Y	As required by MIL-STD-1553B 4.3.3.5.3.1
4 –8	RT Address	Y	As required by MIL-STD-1553B 4.3.3.5.3.2
9	1553 Message Error	Y	As required by MIL-STD-1553B 4.3.3.5.3.3
10	Instrumentation	N	Shall be set to logic zero as required by MIL-STD-1553B
11	Service Request	N	Shall be reset to logic zero as required by MIL-STD-1553B
12 – 14	Reserved	N	Reset to logic zero as required by MIL-STD-1553B
15	Broadcast Command Received	Y	Shall be set to logic one to indicate that the last command received was a broadcast command or logic zero to indicate that the last command was not a broadcast command.
16	Busy	Y	As required by MIL-STD-1553B 4.3.3.5.3.8.

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Table 5-5 MIL-STD-1553B Status Word Implementation Requirement			
Status Bits	**Function**	**Req'd**	**Implementation Requirement**
17	Subsystem Flag	Y	Shall be set to logic one to indicate that an internal failure exists in the RT or that the requested data may not be valid. RT shall use this bit to indicate detectable internal failures or conditions resulting in the potential of incorrect or corruption of Mil-Std-1553 data.
18	Dynamic Bus Control Accept	N	Shall not be implemented and shall be permanently reset to logic zero.
19	Terminal Flag	Y	Shall be set to logic one to indicate RT fault as a result of self-test. Shall be permanently reset to logic zero if RT does not contain any self-test feature.
20	Parity	Y	As required by MIL-STD-1553B: Odd parity over the preceding 16 bits.

5.7 Data Wrap Around

The BC shall periodically perform a Data Wraparound Test to selected, enabled RT's.

Note: The Data Wraparound Test is used to test the data flow through a RT's transceiver (1553B hardware), initial subsystem interface (memory buffers), and the data bus media (cabling and bus couplers).

The instrument RT shall implement Data Wrap Around function defined in Section 30.7, MIL-STD-1553B using #30 receive and transmit sub-addresses.

5.7.1 Data Wrap Around Test Frequency

The data wraparound test shall occur at a rate of 0 to 32 per second where the maximum is defined by the polling rate.

5.7.2 Data Wrap Around Test Pattern

The data pattern used for the Data Wraparound Test shall be a single 16-bit word.

Note: The BC ping-pongs between two 16-bit data patterns on alternating cycles of the Data Wraparound Test to a given RT. When the data pattern transmitted to a given RT does not match the data pattern received from it, the BC indicates that communication between it and the RT is suspect.

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5.8 Automatic Retry

Communication with each instrument shall start on the primary 1553 bus.

The spacecraft shall retry once on the redundant 1553 bus in the event of communication errors or problems.

There shall be no retry for broadcast.

The capability to re-designate the primary and the redundant 1553 buses in orbit via ground commands shall be provided by the spacecraft.

The spacecraft shall report RT error counts and retry failure counts to the ground.

5.9 Remote Terminal Self Test

The instrument RT(s) shall be capable of performing self-testing by producing the status word in Table 5-5.

5.10 Illegal Command monitoring By Instrument RT

The instrument RT shall be capable of monitoring illegal bus commands.

5.11 Instrument Reset

The spacecraft shall use an instrument command to reset an instrument remote terminal to reinitialize communication.

Instrument Reset commands shall not be encapsulated in CCSDS packets',

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5.11.1 Instrument Reset Format

An instrument Reset command shall be a single 16-bit word that is sent to the instrument on receive the subaddress 28 in Table 5-2.

5.11.2 Instrument Reset Contents

An instrument Reset command word shall contain a code directing either a soft reset or hard reset of the instrument per Table 5-6.

Table 5-6 Instrument Reset Codes

Function	Word Value
Soft Reset	1111 1111 0000 0000 ($FF00_{Hex}$)
Hard Reset	0000 0000 1111 1111 ($00FF_{Hex}$)
No-op	All Others

5.11.2.1 Hard Reset

A instrument hard reset shall cause the remote terminal and the associated processor to restart in the same manner as a power-on-reset within the instrument.

Note: It is not currently anticipated that the hard reset will be used.

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5.11.2.2 Soft Reset

A instrument soft reset shall cause the remote terminal and associated processor to restart communications services by reinitializing all remote terminal variables and or registers.

5.12 1553 Bus Initialization

The BC shall initialize with all instrument MIL-STD-1553B bus 1553 Messages disabled.

5.12.1 Autonomous 1553 Message Enabling

The spacecraft shall contain stored sequences that enable 1553 Messages when instrument power is turned on.

Table 5-7 defines the 1553 Message traffic for the MIL-STD-1553B bus and includes the 1553 Message ID, transmitting and receiving unit, sub-addresses, 1553 Message frequency, and additional comments where warranted.

Additional 1553 Message are enabled by ground commands.

Notes: This is done to prevent the BC from initiating communication with a RT that is not ready to communicate (e.g., a RT that is powered off).

Table 5-7 Enabled 1553 Message

Item	1553 Message Id	Transmit Unit	Receive Unit	Freq (Hz)	Size (Wd)	Comment
1	General Purpose 1553B Message	BC	RT	8	128 max	The receive unit, receive subaddress, and 1553 Message size are determined by the command received.
2	Time Code	BC	Broadcast	1	47	Within 100-900 ms before the Time of Day pulse
3	Data Wraparound	BC	RT	TBD	1	
4	Data Wraparound	RT	BC	TBD	1	Same time as above Data Wraparound Test.
5	Data Ready Indicator	RT	BC	TBD	1	
6	Data	RT	BC	TBD	512 max	When DRI changes.
7	End of Data Transfer Cycle	BC	RT	TBD	1	After the above Data transfer has occurred.
8	Command / Memory Load Telecommand Packet	BC	RT	TBD	512 max	As needed.

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5.13 Instrument Telecommands (Commands and Memory Loads)

The spacecraft bus controller (BC) shall control the transfer commands and memory loads to the instrument by conducting a sequence of BC-to-RT transfers defined in Section 4.3.3.6.2 or single RT to RT Transfers (from a spacecraft RT to an instrument RT) defined in Section 4.3.3.6.3of MIL-STD-1553B using specified instrument RT receive sub-addresses.

Comment: Should delete the word single to make it generally applicable.

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5.13.1 First Subaddress

Each packet shall start at the first Instrument Command or Memory Load subaddress in Table 5-2.

5.13.2 Last Subaddress

No packet shall exceed the total number of Instrument Command or Memory Load subaddresses in Table 5-2.

5.13.3 Transfers Exceeding the Sub-address Space

For multiple consecutive 1553 Message that exceed the number of available sub-addresses, once the last available sub-address has been used the sub-address sequence shall be restarted after a minimum delay of 4.0 microseconds (inter-1553 Message gap) as determined by the bus controller.

5.13.4 Telecommand Maximum Rate

At predefined intervals, the minimum and maximum to be documented in the UIID, the BC shall transfer any currently received commands from the spacecraft on-board computer or ground terminal.

5.13.5 Command Constraints

All instrument constraints related to the usage of any sub-address shall be documented in the UIID.

5.14 Instrument Combined Data Bus Rates

The maximum peak rates that the spacecraft transmits commands and broadcast information to the instruments combined with, collected telemetry and science data (including polling traffic) from the instruments shall not exceed the values in Table 5-8 TBR.

The maximum duration of a data transfer cycle (in number of 1553 Messages), the maximum frequency of polling is reflected in Table 5-8.

For each bus cycle, there is a minimum of 100 percent margin.

5.14.1 Instrument Telemetry Buffering

The instrument shall provide buffering for those periods of time where the data rate of transfer is above the average.

Deleted: <#>Commands and Memory Loads Transfer¶
The spacecraft shall deliver the following data to the specified instrument RT receive sub-addresses by conducting single BC to RT Transfers defined in Section 4.3.3.6.1, or single RT to RT Transfers (from a spacecraft RT to an instrument RT) defined in Section 4.3.3.6.3 of MIL-STD-1553B:¶
<#>Command and Memory Load Sub-addresses¶
Command and memory load sub-addresses shall be as listed in Table 0-1.¶

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			Peak Data Rates (Kbps)					
	Polling Rate	1553 Messages	Bus Traffic				Bus Rate	Bus Rate
	Frq	per poll						
Sensor	(Hz)	Ea Sample	**OH**	**TLM**	**TC**	**Brdcst**	**100% Retry**	**Total**
ATMS	8.00	16		30.00		0.752	31	62
OMPS	23.00	32		180.00		0.752	181	362
ERBS	3.00	16		10.50		0.752	12	24
TSIS	9.00	16		33.60		0.752	35	70
GPSOS	25.00	32		200.00		0.752	201	402
ALT	7.00	16		24.00		0.752	25	50
ADCS	7.00	16		26.00		0.752	27	54
CAPS	15.00	32		120.00		0.752	121	242
SS	4.00	16		15.00		0.752	16	32
SARSAT	1.00	4		0.10		0.752	1	2
SESS1	1.00	4		0.10		0.752	1	2

Table 5-8 1553 Instrument Total Combined Data Rates (TBR)

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5.15 1553 Message Timing

The timing of packet transfers via the MIL-STD-1553B bus shall be as shown in Figure 5-1.

5.15.1 Inter-1553 Message Gap

The bus controller shall provide a minimum gap time of 4.0 microseconds between sub-addresses as shown by "T" in Figure 5-1.

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5.15.2 Response Time

The RT shall respond to a valid command word within the time range of 4.0 to 12.0 microseconds as shown by "T" in Figure 5-1.

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5.15.3 Time Out

A 1553B remote terminal shall implement an automatic time-out.

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5.15.3.1 Time Out Effect on End of Data Transfer Cycle

In the event the spacecraft fails to signal the End of Data Transfer Cycle to the instrument, this time-out signal shall be functionally equivalent to the End of Data Transfer Cycle, Section 6.4.5.1, signal to prevent disruption of data transfer and instrument operations.

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5.15.3.2 Time Out Delay

The minimum time a remote terminal or bus controller shall wait before considering that the response has not occurred shall be 20 microseconds as shown by "T" in Figure 5-1.

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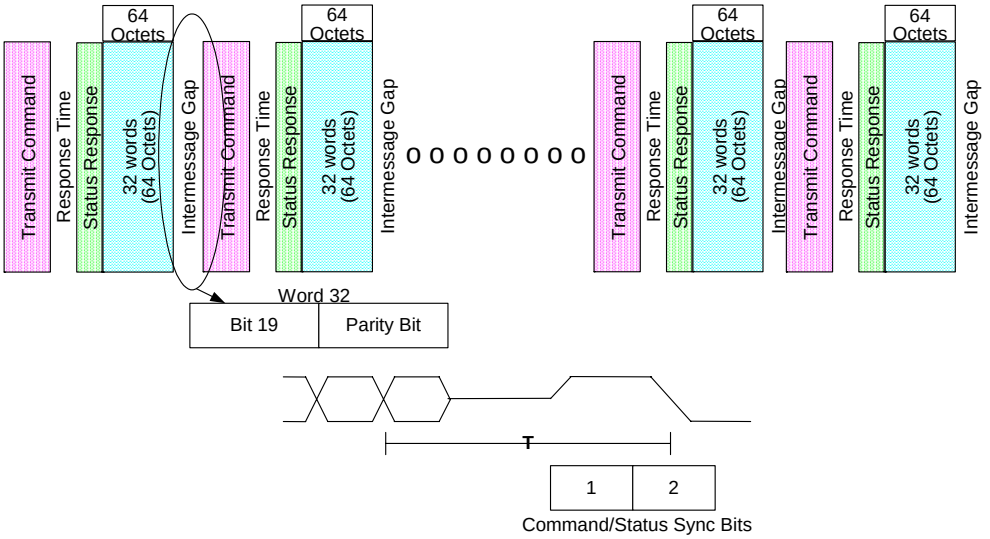

Figure 5-1 Packet Transfer Timing

5.16 1553 Errors

5.16.1 Errors Detected

The BC is capable of detecting various errors that occur on the 1553B bus, perform retries where warranted, and log bus errors for inclusion in the spacecraft Housekeeping Data stream. The BC makes use of existing 1553 chip technology for all 1553B communication. As such, there are certain errors that are detected by the chip itself. All errors detected by the chip generate an interrupt for the host CPU to process. Table 5-9 lists all of the errors detected by the BC along with a brief description of the error.

Table 5-9 Bus Controller Detected Errors

Error	**Description**
Error in a RT's response during the Data Wraparound Test	The data sent to a RT while performing the Data Wraparound Test does not match the data received from the RT. Communications between the BC and RT are suspect.
Bus cycle overrun	The BC did not receive the End of Command Block List interrupt for the set of data transfers initiated in the previous bus cycle. Data transfers may still be active.
1553 Message Error detected by the 1553 chip	The 1553 chip checks data and control words for proper format according to MIL-STD-1553B. Improperly formatted data or control words will cause the 1553 chip to signal a 1553 Message

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Table 5-9 Bus Controller Detected Errors	
Error	**Description**
	Error.
No response from a RT	The 1553 chip verifies that a RT begins transmitting its Status Word within 14 microseconds of receiving a valid command word. It is important to note that RTs do not transmit their Status Words in response to a BC broadcast.
Status Word response with the 1553 Message Error bit set to logic "1"	The 1553 Message Error (ME) bit was set in a RT's 1553B Status Word. A RT will set its ME bit when an invalid data 1553B word is received, an illegal command is received, or an error in the data word count is detected.
Status Word response with the Busy bit set to logic "1"	The Busy bit was set in a RT's 1553B Status Word. An RT uses this bit to indicate to the BC that it cannot comply with the command received. The RT cannot move data to or from the 1553B bus.
Data Overrun detected by the 1553 chip	The 1553 chip was unable to access 1553B shared memory within the time allowed. This would indicate that the host processor was accessing the memory thereby locking out the 1553 chip.
Illegal Command Error detected by the 1553 chip	The 1553 chip detected improperly formatted command blocks. This includes incorrectly formatted RT-RT command blocks.
Retry Failure detected by the 1553 chip	The indicated number of programmed retries has failed.

5.16.2 Errors Logged

The BC also maintains an Interrupt Log List (ILL) that allows the host CPU to review interrupts in chronological order. Each entry in the ILL contains an Interrupt Status Word, a pointer to the Command Block causing the interrupt, and a pointer to the next entry in the list. On the BC, the ILL is sized for a maximum of 32 TBR entries as performed by the selected chipset and documented in the UIID.

If more interrupts are generated during the course of a 1553B bus cycle, the BC will either overwrite the last entry in the list, or, circulate back to the first entry in the list and overwrite that entry, as performed by the selected chipset and documented in the UIID.

5.16.3 1553 Message Error Retry

When a 1553 Message Error is detected (via the RT Status Word or by the BC), an RT is busy (as indicated by its Status Word), or a RT fails to respond, the BC shall direct one retry of the 1553 Message transfer on the alternate bus.

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The BC provides 1553B bus error telemetry that reports if a 1553 Message transfer retry was unsuccessful (i.e., retry failure), if the bus cycle was overrun, the number of erroneous RT responses (during the Data Wraparound Test), the number of RT response time-outs, the number of 1553 Message Errors and the number of BC detected 1553B fault interrupts (Data Overrun and Illogical Command).

5.16.4 Erroneous Received 1553 Message

Data contained within an erroneously received 1553 Message shall be discarded.

Deleted: <#>Telecommand Interval¶
Each instrument shall be capable of accepting a maximum combined command and memory load rate not to exceed 32 (TBR) packets per second.¶
¶

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6 DATA FORMATTING

6.1 CCSDS Packet

All CCSDS packets shall have the total number of octets, including all headers and data, be an even number.

6.1.1 Octet Padding

Padding-octets, added to make a CCSDS packet octet count an even number, shall be inserted at the least significant end of the data field as shown in Figure 6-1.

Primary Header	Secondary Header	Data CCSDS octet 0 to Data CCSDS octet n		Padding as Required
Headers		Most Significant Data CCSDS octet	Middle Data CCSDS octets	Least Significant Data CCSDS octet

Figure 6-1 Padding for Even Numbered CCSDS octets

6.1.2 APIDs

Each RT physical address shall support multiple APIDs that uniquely identify specific unit application processes.

All APIDs, except for the one fixed for ground commands in Table 6-2, shall be reprogrammable prior to launch without instrument removal from the spacecraft.

The initial values for satellite APIDs are listed in Appendix A, APID Initial Assignments. Final APID assignments shall be documented in the UIID.

6.2 Telecommand Formatting

Telecommand packets shall all be formatted as CP_PDU source packets per CCSDS 701.0-B-2 and the figures for the specific packet types shown in Table 6-1.

6.2.1 CRC and Checksums

The usage of CRC or checksums for commands shall be at the discretion of of the instrument provider.

The spacecraft contractor discourages the use of these codes for general commands.

Instrument memory and table loads may want to use checksum.

6.2.2 Documentation

All instrument commands and memory load packets shall be documented in the UIID.

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6.2.3 Uplink CCSDS Packet Set (CPS) Size

Instruments shall not require a single CCSDS Packet Set to be greater than 40,760 bits (one-tenth (1/10) of the minimum uplink total bandwidth opportunity which is defined to be ½ the framed uplink data rate over a six (6) minute period where framing efficiency is 1019/1024).

$$\left\lceil \frac{\left(1019/1024\right) \times 125{,}000 \times 6}{2} \Big/ 10 \right\rceil \approx 37316\ bits \approx 5\ packets \cong L \geq 40760\ \text{bits}$$

Table 6-1 Telecommand Types and Packet Sizes

Source Spacecraft/ Ground	Tele-command Packet	Packet Length in CCSDS octets Including Headers	Required / Optional	Segment or Standalone	Figure	
Both	Command	Maximum 256	Required	Both	Figure 6-2 Figure 6-3 Figure 6-4 Figure 6-5	
Both	Memory Load	Maximum 1024[a]	Required	Both	Figure 6-2 Figure 6-3 Figure 6-4 Figure 6-5	Figure 6-6

6.2.4 Partial Packets

The spacecraft shall never forward to an instrument an incomplete CCSDS Packet.

Ground commands and memory loads are transmitted to the instrument upon completion of packet receipt. Partial packets contained in separate telecommand frames are collected into the whole packets to be forwarded.

[a] The maximum packet size is defined by the source of the packet. Ground packets must not exceed 1019 CCSDS octets in size due to the telecommand frame restrictions. SC sourced packets may be allowed to reach 1024 CCSDS octets.

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6.2.5 Partial CCSDS Packet Sets

The spacecraft shall forward to the instrument all CCSDS Packets as they are received without regard to CCSDS Packet Segmentation.

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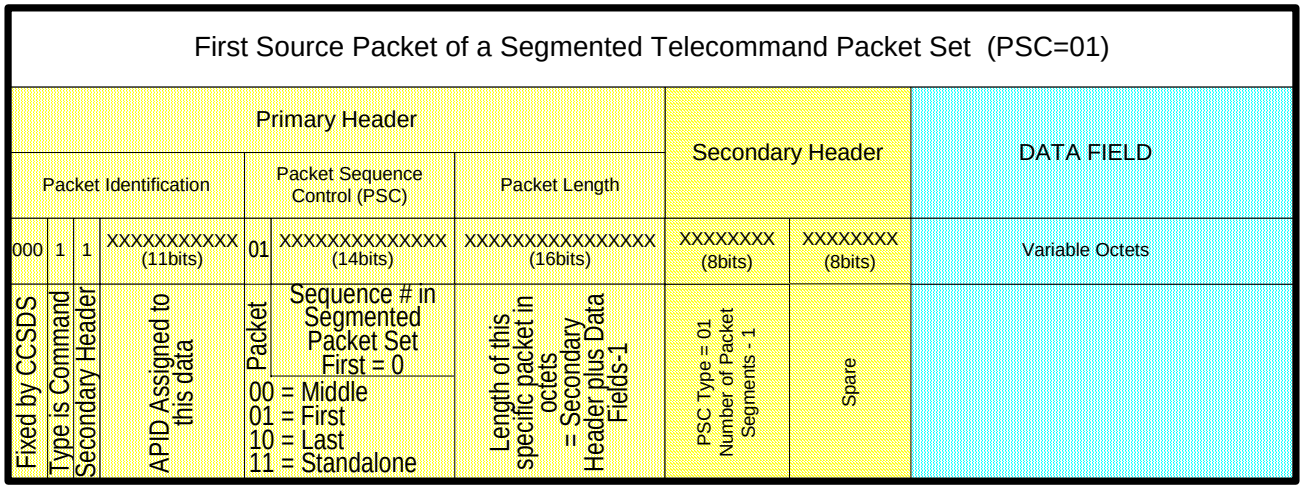

Figure 6-2 Telecommand Segmented Data Packet – First Segment

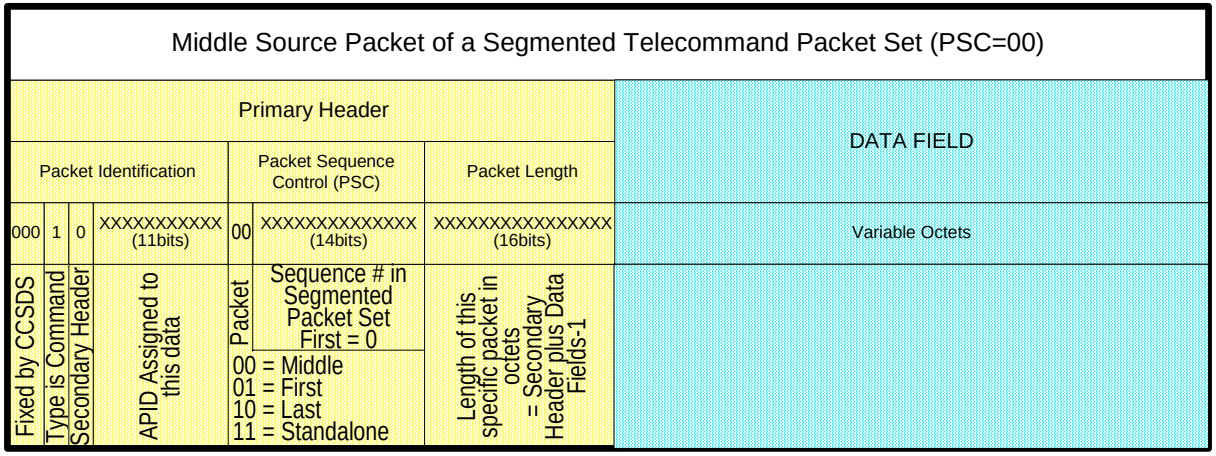

Figure 6-3 Telecommand Segmented Data Packet – Middle Segment

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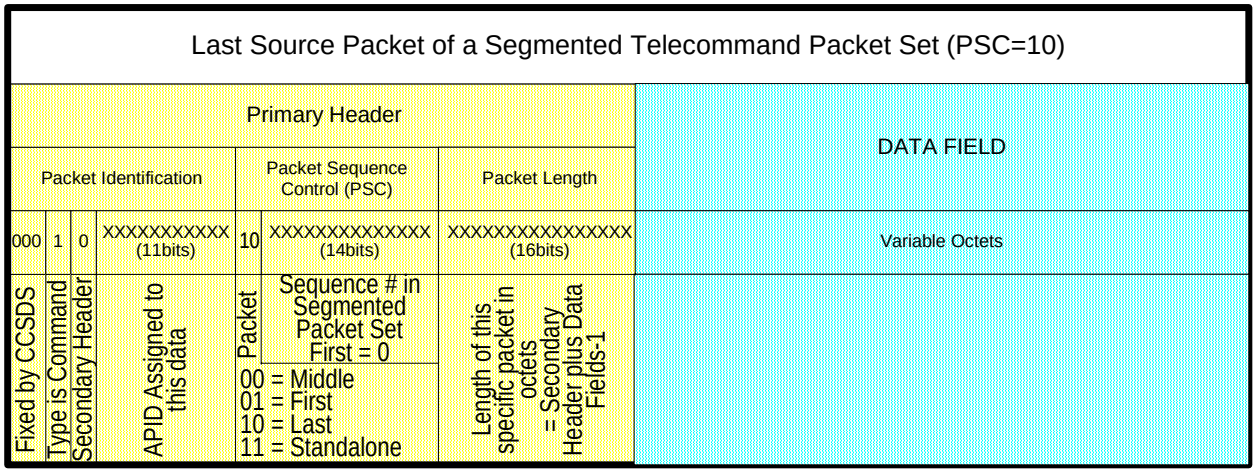

Figure 6-4 Telecommand Segmented Data Packet – Last Segment

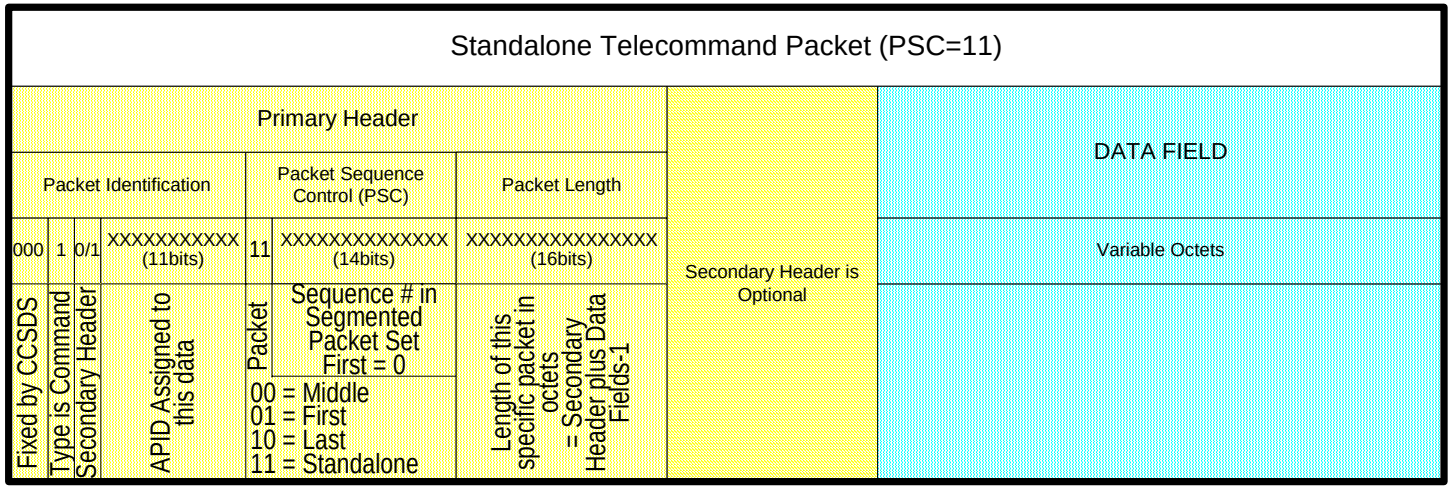

Figure 6-5 Telecommand Non-Segmented Data Packet – Standalone Segment

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Memory Start Address (4 octets)	Data Size (4 octets)	Memory Data Field (Includes Software arithmetic Checksum) (Variable length, Integral even number of octets)

Figure 6-6 Memory Load and Dump Data Field Format

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6.2.6 Segmented Uplink Protocol

The first packet of a CCSDS Packet Set shall have a Packet Sequence Control (PSC) of binary "01".

The last packet of a CCSDS Packet Set shall have a PSC of binary "10"

The middle packets of a CCSDS Packet Set shall have a PSC of binary "00"

The first packet of a CCSDS Packet Set shall contain in the secondary header the number of packet segments – 1.

The first packet of a CCSDS Packet Set shall have the CCSDS sequence counter of 0. Each subsequent packet's sequence counter shall be monotonically increasing.

If a packet has a sequence counter out of order the instrument shall reject the CCSDS packet set and report the error in telemetry.

Instruments shall be capable of accepting uplink Data Sets, including Segmented commands and Segmented loads where there may be other commands and time delays as long as one (1) second inserted between the CCSDS Packet Segments that comprise the CCSDS Packet Set.

Instruments shall detect a time delay greater than one (1) second between receipt of CCSDS Packet Segments and as a result terminate the load or command.

6.2.7 Non-Segmented Uplink 1553 Messages

The packet shall have a PSC of binary "11".

The uplink packet shall have the CCSDS sequence counter of 0.

6.2.8 Telecommand/Memory Load Data Transfer process

a. Each CCSDS packet transfer shall be a separate operation.

b. If the command or memory load is comprised of segmented packets, the first CCSDS packet segment shall contain in the secondary header the number –1 of CCSDS packet segments in the CCSDS packet set transfers (per Figure 6-2).

c. Command and memory load transfers shall always start with the first subaddress listed for the purpose in Table 5-2.

d. The instrument shall read this address and determine the number of words (word = 2 CCSDS octets = 16 bits) from the primary header. The number of words is defined as packet length plus one (W +1).

e. The number of subaddresses to be read is defined by $Round_up\left[\frac{(W+1)}{2}\Big/32\right]$.

f. The instrument shall read number of packet segments (P), if more than one is required for the CCSDS packet set, from the secondary header. The number of CCSDS packets to be received is defined by $P+1$.

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Deleted: or standalone CCSDS packet of a command or memory load

Deleted: in the secondary header per Figure 3.3.3-7 for

Deleted: and Figure 3.3.3-10 for standalone packet transfers

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Deleted: and the number of packet segments (P), if more than one, from the secondary header.

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g. For CCSDS packet sets the instrument shall complete reading the first CCSDS packet and wait for next CCSDS packet that will begin again with the first subaddress in listed for the purpose in Table 5-2.

h. A new CCSDS packet shall not begin until the last CCSDS packet is complete.

This does not imply a complete CCSDS packet set, only a standalone packet or packet segment.

i. A new CCSDS packet or packet set, using the same APID, shall not be initiated prior to the completion of another CCSDS packet or packet set.

j. The instrument shall be capable of receiving a CCSDS packet set with another CCSDS packet between packet segments using the same APID.

k. The instrument shall be capable of breaking up memory loads into small enough CCSDS packet sets such that it may be accomplished over multiple contacts.

l. The instrument shall the detect the initiation of a new CCSDS packet or packet set, using the same APID, prior to completion of another CCSDS packet set.

   - Detection shall cause all packet segments associated with the as yet unfinished CCSDS packet set to be abandoned.

m. Abandoning CCSDS packet segments and or CCSDS packets due to errors shall be indicated in telemetry.

n. The instrument shall be capable of detecting the complete reception of a packet, packet segment and CCSDS packet set by using the header data and counting octets.

Note: A command or memory load is only a BC to RT transfer defined in Section 4.3.3.6.1 of MIL-STD-1553B.

6.2.9 Telecommand APIDs

Each instrument shall have unique APIDs allocated for spacecraft and ground commands (2) and memory loads (2).

6.2.9.1 Command APIDs

There shall be two (2) APIDs for commands.

a. One APID shall define a command from the ground.
   - The APID assigned to ground commands shall be per Table 6-2.
   - The APID assigned to ground commands shall not be alterable.

b. The other APID shall define a command from the spacecraft.

Deleted: <#>Packetization for Commands and Memory Loads¶
Unless otherwise specified, all commands and memory loads delivered to the instrument shall be formatted in accordance with the CCSDS AOS packet defined in CCSDS 701.0-B-2.¶
<#>Command and Memory Load Packet Length¶
A single command or memory load packet shall be per section 6 (and the note therein), or shorter.¶

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Table 6-2 Fixed Command APID Assignments (TBR)		
Instrument	**Hex**	**APID** MSB LSB Bit 0 Bit10
OMPs	227	010 0010 0111
ATMS	207	010 0000 0111
ERBS	097	000 1001 0111
TSIS	267	010 0110 0111
GPSOS	247	010 0100 0111
SARR	2C7	010 1100 0111
SARP	2E7	010 1110 0111
ALT	287	010 1000 0111
ADCS	2A7	010 1010 0111
APS	4C7	100 1100 0111
Special	527	101 0010 0111
SESS	407	100 0000 0111

6.2.9.2 Memory Load APIDs

There shall be two (2) APIDs for memory loads.

a. One APID shall define a memory load from the ground.

b. The other APID shall define a memory load from the spacecraft.

6.2.10 Commands and Memory Loads

6.2.10.1 Spacecraft Commands and Memory Loads

Instruments shall be capable of receiving “near simultaneously” spacecraft generated commands, and ground generated memory loads.

6.2.10.2 Ground Commands and Spacecraft Memory Loads

Instruments shall be capable of receiving “near simultaneously” ground terminal generated commands and spacecraft generated memory loads.

6.2.10.3 Spacecraft Commands and Ground Commands

Instruments shall be capable of receiving “near simultaneously” spacecraft generated commands and ground generated commands.

6.2.10.4 Spacecraft Memory Loads and Ground Memory Loads

Instruments shall be capable of receiving “near simultaneously” spacecraft generated memory loads and ground generated Memory Loads.

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6.2.11 Spacecraft/Ground Memory Load Authority

Simultaneous receipt of ground terminal generated memory loads and spacecraft generated memory loads shall result in only the ground memory load being executed.

6.2.12 Spacecraft/Ground Command Authority

Simultaneous receipt of ground terminal generated commands and spacecraft generated commands shall result in both commands being executed.

6.2.13 Command/Memory Load Authority

Simultaneous receipt of commands and memory loads shall result in both commands and memory loads being executed.

6.3 Broadcast Formatting

All 1553 RT's shall be capable of receiving broadcast 1553 Message.

6.3.1 Ephemeris and Time Code Data

Table 6-3 Time Code Format

T-Field			
	Day	**msec of Day**	**usec of msec**
Bits	**16**	**32**	**16**
Time Resolution of 1 usec	**0 to (2^{16}-1)**	**0 to 86,399,999**	**0 to 999**

6.3.2 Time Code Data and Format

All Instances of time code data shall be spacecraft time presented in CCSDS segmented Time Code (CDS) format defined in CCSDS 301.0-B-2 .

The time code represents spacecraft time at the next Epoch(i.e., at the tone the time will be).

6.3.3 Time Code and Ephemeris Data Transfer

The broadcast time of day and ephemeris data will arrive at the instrument between 100ms and 900ms prior to the arrival of the time of day pulse.

The time code is broadcast to all RTs over receive subaddress in Table 5-2.

6.3.4 Time Code Data Accuracy Syncopation

Each Time-of-Day data packet shall arrive at the instrument 1 second ± 4 milliseconds of the previous Time-of-Day data packet arrival as shown in Figure 6-7.

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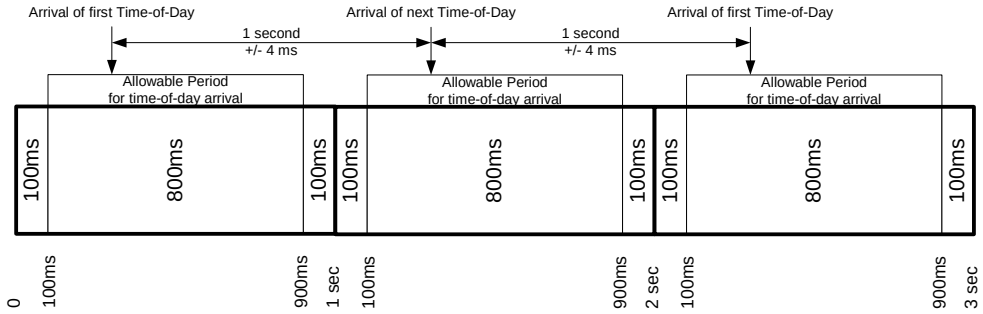

Figure 6-7 One Second Time-of-Day Jitter

6.3.5 Time Code Effectivity

The broadcast time shall become effective upon receipt of the Time-of-Day pulse that follows.

6.3.6 Time Code Data Accuracy With Time-of-Day Epoch

The time code data associated with the time-of-day Epoch shall be accurate to within 1 ms of the international standard UTC time.

6.3.7 Time Code Data Epoch

The epoch shall be January 1, 1958.

6.3.8 Missing Time Code Data

The instrument shall be capable of continued normal mode science observations, until transfer to safe mode is effected, if the time code data is not received.

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6.3.9 Ephemeris

The spacecraft shall provide ephemeris and attitude data per Table 6-4

The CCSDS formatting of the ephemeris and attitude data shall be per Figure 6-8

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Octets			Data Element				Time Tag	Format
Qty	First#	Last #	Name	Units	Knowledge	Resolution	Accuracy	
8	1	9	Position Time Stamp	Microseconds	10 us	1 us (TBR)	< 1ms (TBR)	CCDS CDS
4	10	13	Spacecraft Position - X	Meters ECI XYZ (TBR)	< 20 meters (TBR)	1 meter (TBR)	< 1ms (TBR)	2s Complement (TBR)
4	14	17	Spacecraft Position - Y					
4	18	21	Spacecraft Position - Z					
8	22	29	Velocity Time Stamp	Microseconds	10 us	1 us (TBR)	< 1ms (TBR)	CCDS CDS
4	30	33	Spacecraft Velocity - X	Meters/sec ECI XYZ rates (TBR)	1 meter/sec (TBR)	1mm/sec (TBR)	< 1ms (TBR)	2s Complement (TBR)
4	34	37	Spacecraft Velocity - Y					
4	38	41	Spacecraft Velocity - Z					
8	42	49	Attitude Time Stamp	Microseconds	10 us	1 us (TBR)	< 1ms (TBR)	CCDS CDS
4	50	53	Roll	Arcseconds Euler angle to orbit frame (TBR)	9.5 arsec (TBR)	< 0.1 arcsec (TBR)	< 1ms (TBR)	2s Complement (TBR)
4	54	57	Pitch					
4	58	61	Yaw					
8	62	69	Attitude Time Stamp	Microseconds	10 us	1 us (TBR)	< 1ms (TBR)	CCDS CDS
4	70	73	Roll Rate	Arcseconds/sec Euler angle rates (TBR)	0.1 arcsec/sec (TBR)	.01 arcsec/sec (TBR)	< 1ms (TBR)	2s Complement (TBR)
4	74	77	Pitch Rate					
4	78	81	Yaw Rate					

Table 6-4 Ephemeris and Attitude Data Parameters

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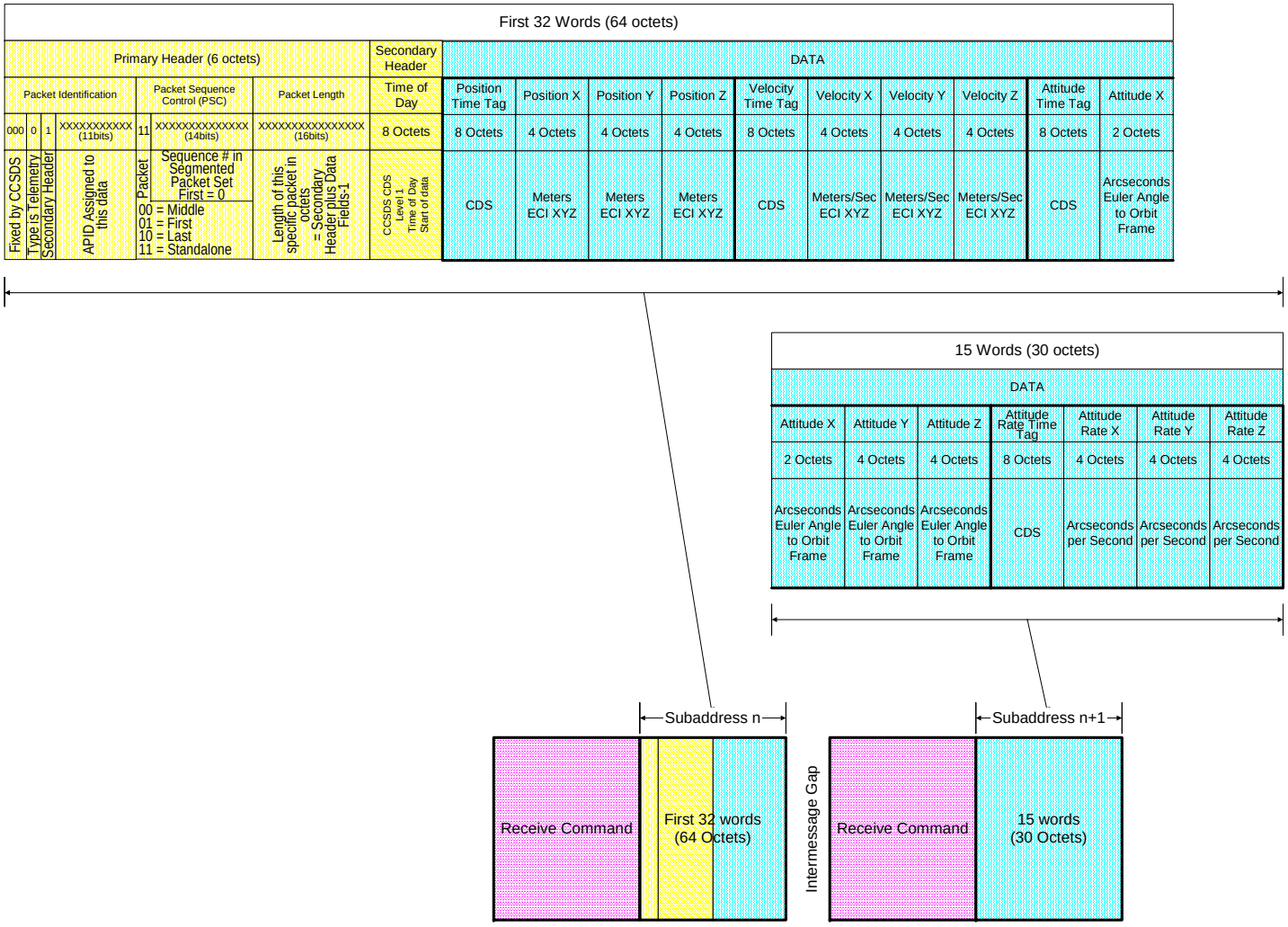

Figure 6-8 Broadcast Time of Day and Ephemeris Data Packet Format

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6.4 Downlink Formatting

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Telemetry packets shall all be formatted as CP_PDU source packets per CCSDS 701.0-B-2 and the figures for the specific packet types shown in Table 6-5.

Data assignment to APIDs shall require approval of the TSPR contractor and shall be documented in the UIID.

Each of the following data types shall employ one or more APIDs as appropriate to allow optimal data extraction to meet EDR performance at each processing terminal[a] including the limiting effects of link bandwidth.

Table 6-5 is intended to be superset of the formats that might be used. It does not require that all formats be used. If there are additional format types desired by the instrument provider they may be added to the UIID following agreement by the spacecraft contractor.

Deleted: *who may also choose to add the new type to the superset listed in the IRD*

Table 6-5 includes telemetry packet types that may consist of segmented CCSDS packets, and that the maximum size of each CCSDS packet is as defined in Table 3.3-1. If a packet does not have a segmented format shown it is intended to only be standalone.

6.4.1 Instrument Telemetry Data

The instrument shall produce telemetry data sufficient for instrument status and health monitoring at the MCC during all instrument modes except off/survival.

The telemetry data shall at a minimum consist of housekeeping data and LEO&A data.

The instrument may optionally generate telemetry monitor data.

The instrument may optionally generate dwell data.

Other data types to be included in the telemetry stream shall be documented in the UIID.

6.4.1.1 Housekeeping Packets

Instrument housekeeping data shall provide status data required to determine if the instrument is functionally performing nominally.

Deleted: Information relating to the state of health of the instrument but not including data contained in any other packet.

The status data may include, but not be limited to the following:

Deleted: Housekeeping data shall provide status data required for instrument status and health monitoring. ¶

- Instrument mode, state and configuration
- Temperatures
- Input current for each power supply service
- Output voltage for each power supply service
- Relay status
- Rotational rates of scan mirrors and other rotating mechanisms.
- Other instrument engineering data required to support instrument

[a] Terminals incorporate all users of the SMD, HRD and LRD links including field terminals.

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Table 6-5 1553 Telemetry Types and Packet Sizes					
User Spacecraft / Ground	**Telemetry Packet**	**Packet Length in CCSDS octets Including Headers**	**Required / Optional**	**Segment or Standalone**	**Figure**
SC	Test Packets[a]	Required 256	Required	Standalone	Figure 6-13
Ground	Memory Dump Packet	Maximum 1024	Optional	Both	Figure 6-9 Figure 6-10 Figure 6-11 Figure 6-12
Ground	Engineering data packets	Maximum 256	Required	Both	Figure 6-9 Figure 6-10 Figure 6-11 Figure 6-12
Ground	Housekeeping packets	Maximum 256	Required	Both	Figure 6-9 Figure 6-10 Figure 6-11 Figure 6-12
Ground	LEO&A Housekeeping packets	Maximum 32	Required	Standalone	Figure 6-13
Ground	Calibration packets	Maximum 256	Optional	Both	Figure 6-9 Figure 6-10 Figure 6-11 Figure 6-12
Ground	Dwell packets	Maximum 256	Optional	Both	Figure 6-9 Figure 6-10 Figure 6-11 Figure 6-12
Ground	Diagnostic packets	Maximum 256	Optional	Both	Figure 6-9 Figure 6-10 Figure 6-11 Figure 6-12
Ground	Science packets (Raw or Processed)	Maximum 1024	Required	Both	Figure 6-9, Figure 6-10, Figure 6-11 Figure 6-12
Spacecraft	Telemetry monitoring packets	Maximum 32	Optional	Standalone	Figure 6-13

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[a] The Data field shall be "$CCCC_{HEX}$".

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6.4.1.1.1 Housekeeping Data Rate

Instrument housekeeping data shall be generated at an orbital average rate not to exceed 2 Kbps.

Housekeeping packets shall be generated synchronous and deterministic over an instrument defined time period.

Housekeeping parameters may be duplicated in the Engineering data or other data streams at the discretion of the instrument provider. However, at all times the data rate allocations for the specific stream must not be exceeded.

6.4.1.2 LEO&A Packets

LEO&A data shall contain the minimum data necessary to determine health and status of the instrument when the spacecraft normal telemetry stream is not available due to link availability or emergency conditions.

6.4.1.2.1 LEO&A Data Rate

Instrument LEO&A packet shall be generated continuously at a rate not exceeding 256 bps

6.4.1.3 Telemetry Monitor Packet

Telemetry Monitor packets shall contain data to be monitored by the spacecraft requiring prescribed actions by the spacecraft.

Telemetry parameters to be monitored, out of limit conditions, and required actions are to be specified in the UIID.

6.4.1.3.1 Telemetry Monitor Data Rate

If the instrument generates telemetry monitor data the orbital average output shall not exceed 256 bps including overhead.

6.4.1.4 Dwell Packets

Dwell packets shall consist of the resulting data of commanded housekeeping data over-sampling to obtain increased bandwidth knowledge for diagnostic purposes.

6.4.1.4.1 Dwell Data Rate

The combined data rate of dwell and housekeeping data shall not exceed 2 kbps.

When generated dwell data may replace some or all of the housekeeping data in order to maintain the 2 kbps allocation.

6.4.2 Mission Data

The instrument shall produce mission data required to generate Environmental Data Records (EDRs) and verify the performance of the instrument.

6.4.2.1 Science Packets

Science packets shall consist of instrument measurement and observation data, whether processed or raw, such that the combination of science data and

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Deleted: Instrument housekeeping data shall be generated continuously such that the average rate over each one-second period is less than 2.5 Kbps.

Inserted: Instrument housekeeping data shall be generated continuously such that the average rate over each one-second period is less than 2.5 Kbps.

Deleted: Instrument housekeeping data shall be generated continuously such that the average rate over each one-second period is within ±25% of the orbital average rate.

Deleted: <#>Housekeeping Data Timeliness¶
The delay between housekeeping data generation and transmission onto the data bus shall not exceed 2 seconds.

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Deleted: *Dwell data is a specific set of data, as defined in the UIID, requested by command to be repetitively sampled for diagnostic purposes.*

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engineering data is, without excess, is sufficient to achieve specified performance.

6.4.2.2 Engineering Packets

Engineering packets shall consist of all engineering data required to meet specified science data processing performance such that the combination of science data and engineering data is, sufficient to achieve specified performance.

6.4.2.3 Calibration Packets

Calibration packets shall consist of resulting data from instrument calibration, alignment or other precision enhancing actions, used to compensate or otherwise reduce science and or engineering data uncertainties.

Calibration data required for instrument data processing shall be defined and documented in the UIID.

6.4.2.4 Memory Dump Packets

Memory dump packets shall consist of the contents of the commanded range of memory or processor register dump. The first packet of the memory dump packets contains in the first 8 octets of the data zone the starting location of the dump as is shown in Figure 3.3.3-6. The instrument may use a single command to initiate a dump even though the dump contents may span multiple packets (segmented or unsegmented).

6.4.2.5 Diagnostic Data

Diagnostic packets shall contain data for instrument diagnostic purposes during normal or diagnostic mode as required by the instrument.

Instrument diagnostic data shall be any instrument data other than normal engineering data and science data that are down-linked to support ground diagnosis of instrument anomalies.

6.4.3 Test Packets

Test packets are special packets used to test the interface of the instrument with the spacecraft. Test packets shall be a stand alone 256 byte CCSDS formatted packet containing $CC_{hex.}$ The instrument shall generate test packets at the rate of one packet per 1553 poll upon receipt of an instrument defined command. The instrument shall continue to generate test packets until commanded to stop.

If the stated data volume or rate for test packets is a driving requirement for an instrument or the interface, the instrument should indicate in the UIID a different test packet generation scheme. In order to reduce the overhead percentage, it is preferred that the volume be reduced by maintaining at-or-near the 256 octets per packet, and reducing the packet rate (rather than maintaining a faster packet rate with fewer bytes per packet).

The parameters being used by that instrument shall be defined in the UIID.

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Comment: The reason for this wording was to limit the housekeeping content so as to meet the desire for encrypting health and status data.

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Test packets shall be a stand alone 256 byte CCSDS formatted packet containing $CC_{hex.}$ for each byte of data generated continuously by the instrument processor and sent to the bus controller at science data packet frequency when commanded by the spacecraft.¶

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Comment: Can not delete dwell since it is in the sensor and spec and TRD.

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Dwell packets shall consist of the resulting data of commanded housekeeping or engineering data over-sampling to obtain increased bandwidth knowledge for diagnostic purposes.¶
Diagnostic Packets

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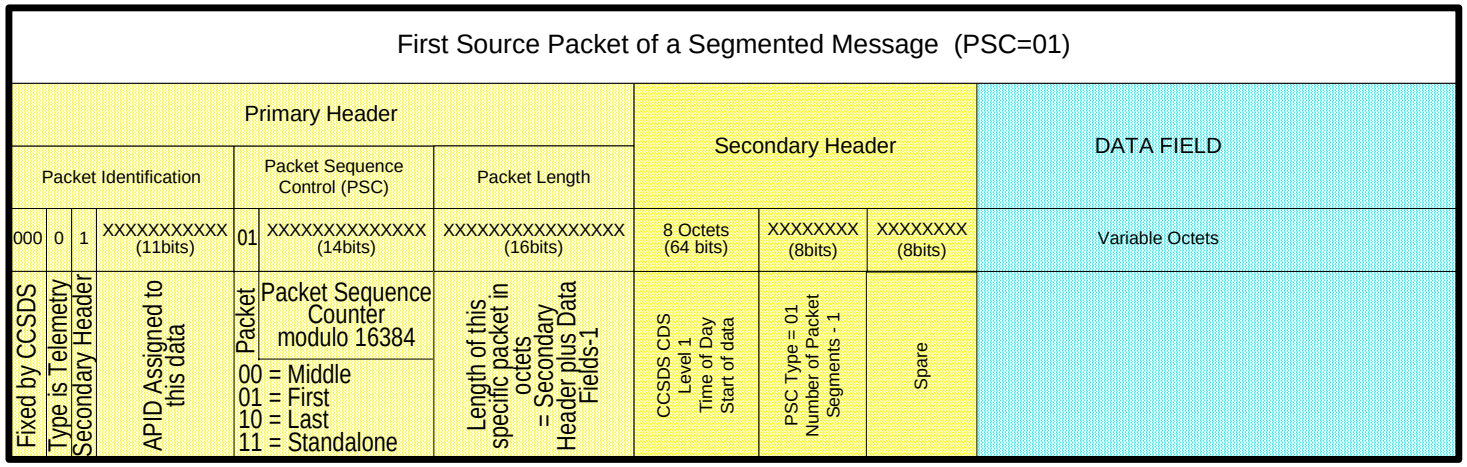

Figure 6-9 Segmented Mission Data &Telemetry Packet – First Segment

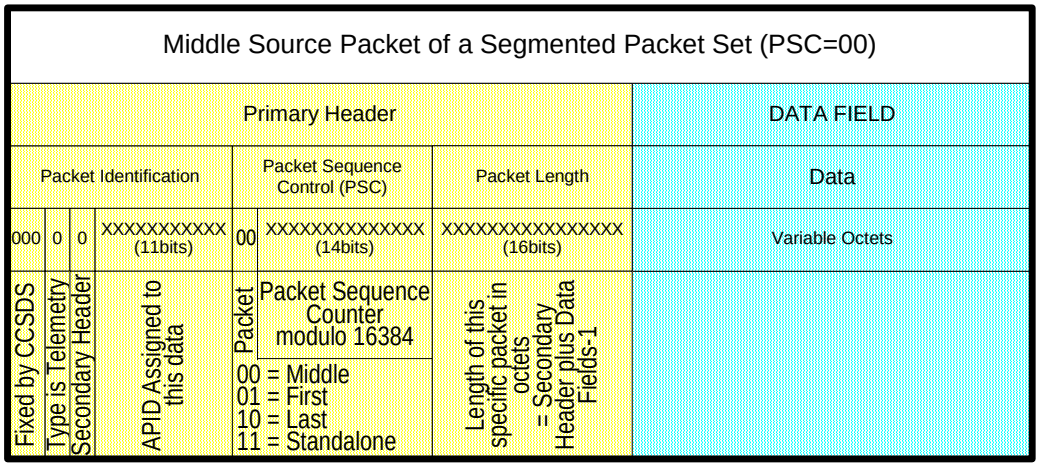

Figure 6-10 Segmented Mission Data & Telemetry Packet – Middle Segment

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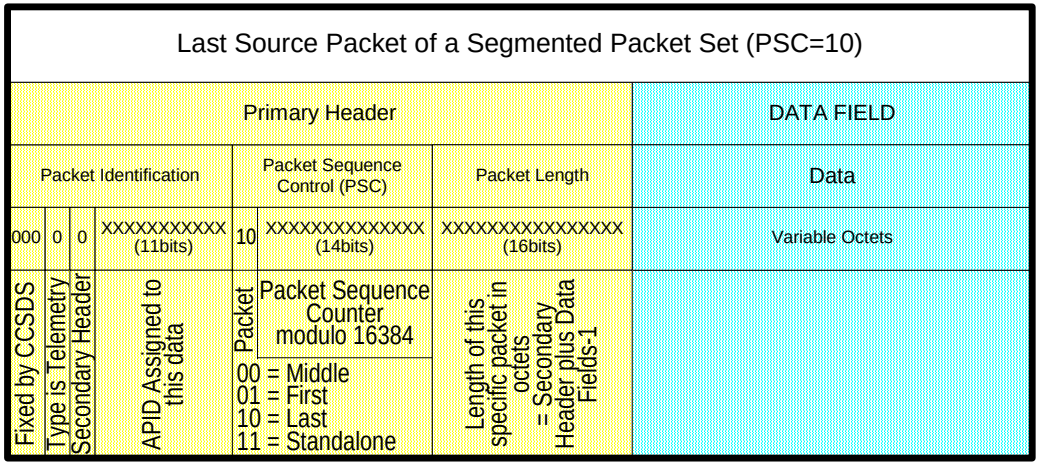

Figure 6-11 Segmented Mission Data & Telemetry Packet – Last Segment

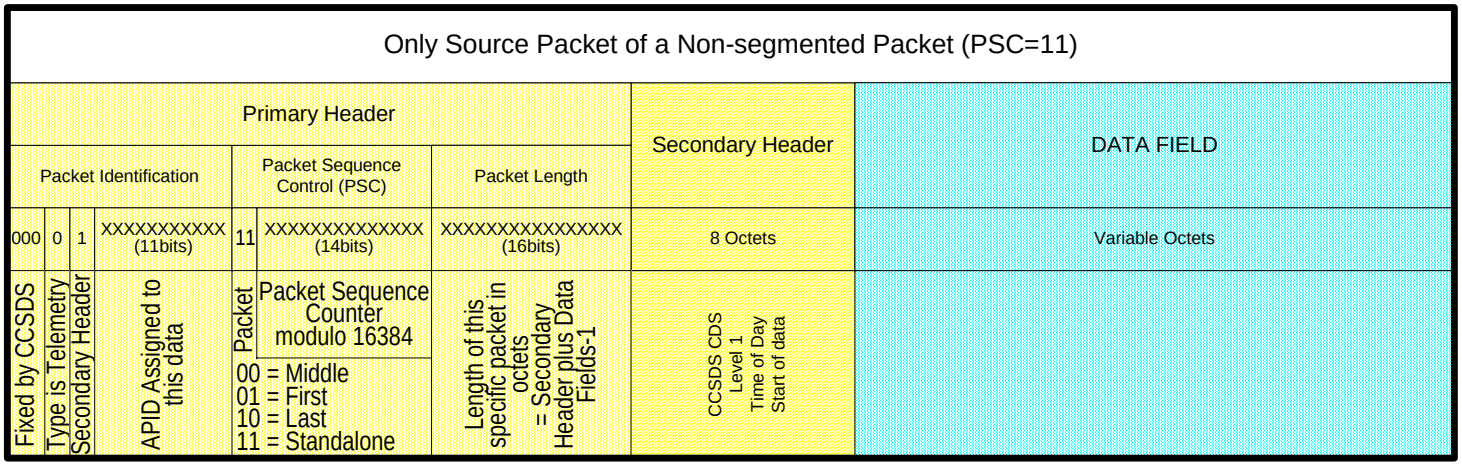

Figure 6-12 Non-Segmented Mission Data & Telemetry Packet – Standalone Segment

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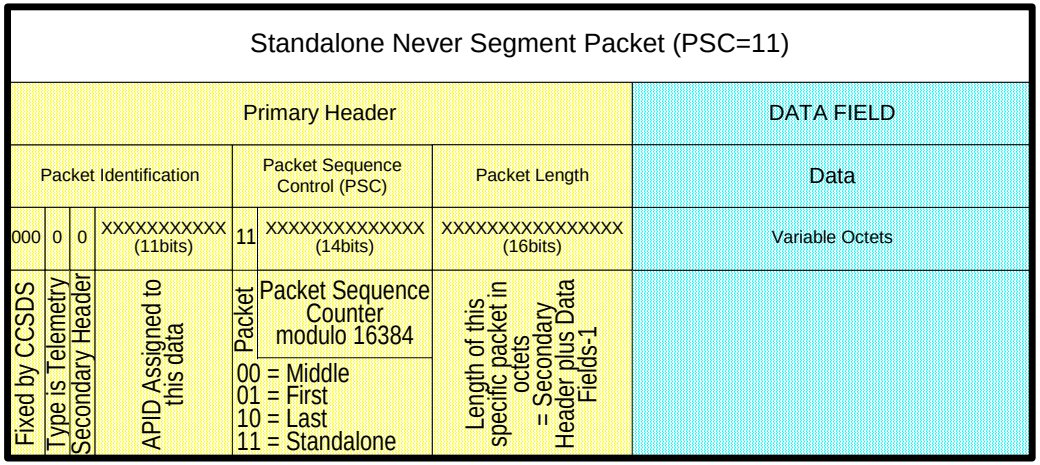

Figure 6-13 LEO&A, Test, and Telemetry Monitor Telemetry Packet Format

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6.4.4 Data Packetization

The size of downlink packets shall not exceed sizes specified in Table 6-5. The instrument contractor shall document in the UIID each APID, its contents, maximum packet size, maximum peak data rate and maximum average data rate including all packet contents[a], for each instrument mode.

The instrument contractor shall document in the UIID the maximum average and peak data rates for each instrument mode.

6.4.4.1 Content and Structure

Data packets using the same Application Process ID shall have the same contents and structure.

Assigning different Application Process ID's shall accommodate different contents and structures.

The instrument shall segment science data packets longer than 1,024 CCSDS octets before transferring to the spacecraft via the 1553 bus as shown in Figure 6-9, Figure 6-10, Figure 6-11, and Figure 6-12.

Each segmented packet shall be 1,024 CCSDS octets in length except for the last one or a standalone packet, whose length shall be less than or equal to 1,024 CCSDS octets.

6.4.4.1.1 Primary Header

6.4.4.1.1.1 APID

Application Process Identifiers (APIDs) contained in segmented packets shall remain the same throughout all CCSDS packet segments part of the data set being sent.

6.4.4.1.1.2 Sequence Flag:

The sequence flag follows the following protocol:

- 01 for the first packet of a segmented packet set
- 10 for the last packet of a segmented packet set
- 00 for the in-between segmented packets
- 11 for stand alone packet

Packets of segmented packet set may proceed from first packet to last packet without any middle packets.

6.4.4.1.1.3 Packet Sequence Count:

The packet sequence count (primary header) shall monotonically increase from one CCSDS packet of an APID to the next CCSDS packet of the same APID. The sequence counter shall continue to monotonically increase across all

[a] Primary header, secondary header and data field

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<#>Total Instrument Data Rate¶
<#>The total instrument data rate averaged over any one-second period shall not exceed the instrument peak data rate specification and shall be documented in the UIID

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<#>The instrument average data rate shall be defined to be the total data for one orbit divided by the orbit period and shall be documented in the UIID.¶

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Deleted: Table 3.3.1-1. Data Rate and Packet Size¶

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<#>Maximum telecommand rates shall be limited by the uplink rate, instrument operational constraints and the load requirements of the instrument.¶
<#>All telecommand and me … [1]

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packets of the same APID. The instrument shall maintain a separate counter for each APID.

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6.4.4.1.2 Secondary Header

The secondary header shall only exist for the first packet, Figure 6-9, of a segmented CCSDS packetized Data Set when the Primary Header Packet Segmentation bits are 01_b, and, a standalone packet, Figure , when the Primary Header Packet Segmentation bits are 11_b.

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6.4.4.1.2.1 Time of Day

a. The time of day shall be coincident with the time of creation of the first data within the data field.
b. The time of day shall employ the format in section 6.3.2, Time Code Data and Format.
c. Where an instrument contractor is not responsible for ultimate EDR performance in which the data is used, the time-of-day inserted into the packet shall be related to the first data within the data field adding an instrument uncertainty less than 1 millisecond on top of the spacecraft uncertainty.
d. The uncertainty of the time-of-day as included in the packet shall be as necessary to provide EDR performance specified in the TRD appendix D including correlation to ephemeris, that contains a 1 ms uncertainty.

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6.4.4.1.2.2 Number of Packet Segments

The number of packet segments field shall contain the total number of packets expected minus one in the full packet set such that the count of packets is from 0.

6.4.4.2 CRC and Checksums

CRC and checksums shall not be implemented in downlink packet headers.

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6.4.5 Instrument Telemetry Data Transfers

A single transfer of data shall be comprised of one or more whole packets.

Packet transfers shall not use fill between individual packets or to complete a 1553 transfer.

Multiple CCSDS packets transported via 1553 shall concatenate the CCSDS packets per Figure 6-14

No inter-1553 Message gap shall be inserted unless the last 1553 Message completed the subaddress transfer.

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6.4.5.1 Instrument Telemetry Data Transfer Process

The spacecraft bus controller (BC) shall control the transfer of instrument telemetry data by conducting a sequence of reads employing RT-to-BC transfers defined in Section 4.3.3.6.2 or RT-to-RT transfers (instrument RT to spacecraft

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RT) defined in Section 4.3.3.6.3 of MIL-STD-1553B using specified instrument RT transmit sub-addresses and the following protocol:

a. At the maximum predefined intervals ($1/Polls\ per\ second$) in Table 5-8 each instrument shall load its telemetry data (1553 message set) up to the maximum 1553 Messages in Table 5-8 into the predefined transmit sub-addresses, in Table 5-3, and update its Data Ready Indicator (DRI).

b. If the 1553 message set contains multiple CCSDS packets and or CCSDS packet segments to be sent during one polling period, no gaps shall exist between any of the CCSDS Packets and or CCSDS Packet Segments as the data is loaded into the 16 subaddresses each containing 32 words of 2 CCSDS octets each through the repetitive cycling of these subaddress until the total 1553 Message Set has been sent.

c. At the appropriate interval, per the polling period in Table 5-8, for each instrument, the BC instructs the instrument to transmit its DRI from transmit sub-address 29 which consists of a single data word.

d. The DRI shall contain the total count of 16 bit data words in the data-set to be read.

e. If the indicator is zero, the spacecraft takes no further action until it is time to poll the instrument again.

f. If the indicator is non-zero, the BC shall instruct the instrument to transmit its data by performing reads of Table 5-3 subaddresses starting with the first subaddress and incrementing the subaddress number as required to retrieve the number of words indicated by the DRI word.

g. If there are more words to be transmitted than are allowable within the Table 5-3 subaddresses, at thirty-two (32) sixteen (16) bit words for a total of sixty-four (64) CCSDS octets per subaddress, the BC shall repetitively cycle through the subaddresses repetitively each time starting at the first subaddress until the total 1553 message set is transmitted.

Note: Each read transfers 64 CCSDS octets of data to the spacecraft.

h. Following the data transfer of the data set, the BC shall write, End of Data Transfer Cycle, a 16-bit word to the instrument's receive sub-address 29 to indicate to the instrument that the data transfer has been completed. The data value written to receive sub-address 29 is an echo of the instrument's DRI.

i. The instrument shall subtract the number of words sent from the DRI value. If the DRI had not incremented, indicating addition of more data, during the just completed data transmission, the value shall be zero.

Note: A write is either a BC to RT transfer defined in Section 4.3.3.6.1 or a RT to RT transfer (spacecraft RT to instrument RT) defined in Section 4.3.3.6.3 of MIL-STD-1553B.

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Deleted: <#>Instrument Telemetry Data Rate¶
The instrument peak data rate of transfer shall be as defined in section 6.5.3.

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Note: This includes science data, housekeeping telemetry, memory dumps, and diagnostic data.

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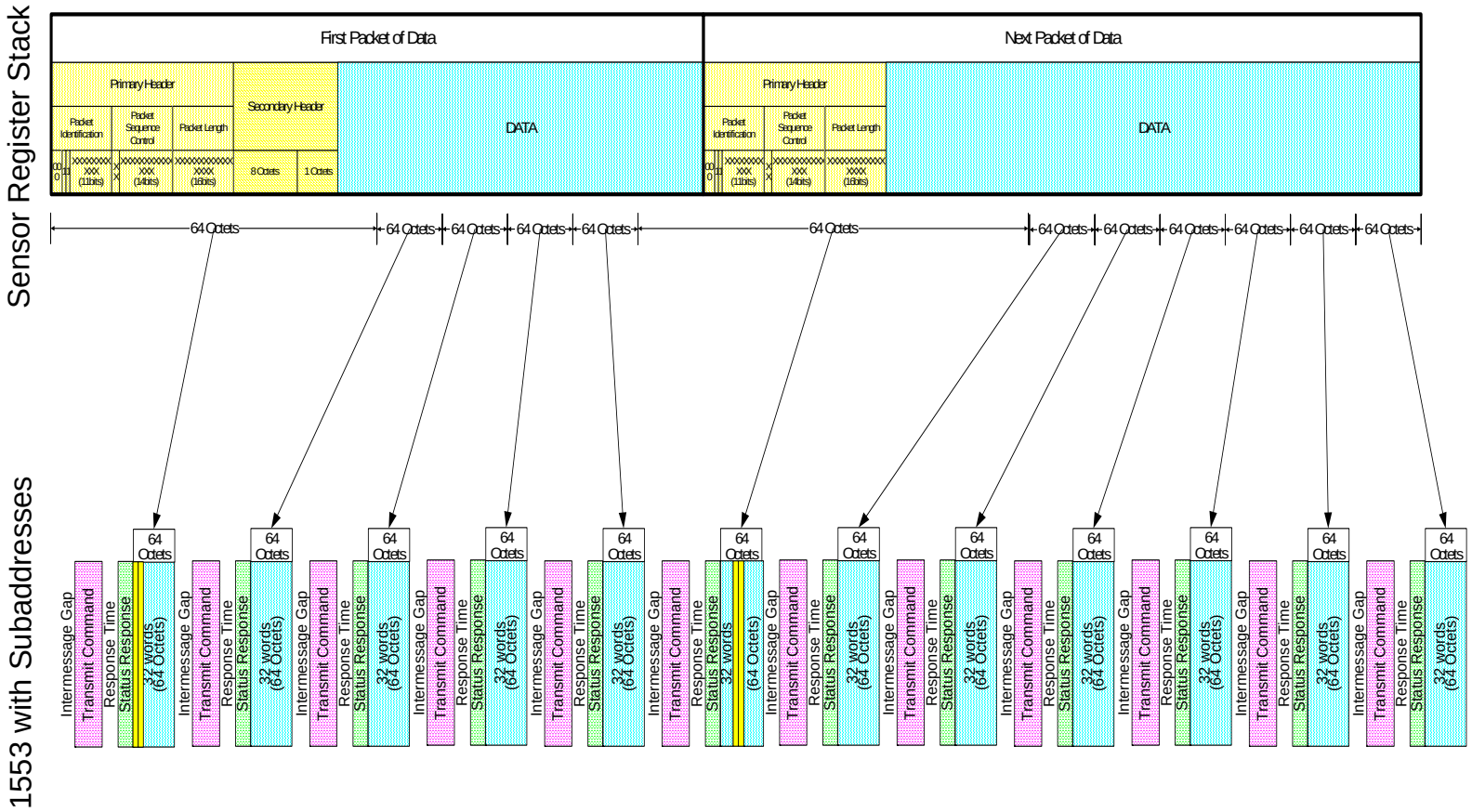

Figure 6-14 Multiple Packets Within a Single 1553 Transfer

7 CONNECTORS

7.1 *Part Number*

The instrument shall use Sabritec connectors, part number 015728-5001, or specify in their UIID the specific connectors used and supply two sets of mating connectors per instrument delivered plus two sets for the construction of test cables.

7.2 *Pin Assignment*

7.2.1 Triaxial Connectors

The center wire of triaxial connectors shall be signal plus (+).

Where color-coded wire is used the color for this wire shall be blue with the minus (-) wire white.

7.2.2 Non-Triaxial Connectors

Non-triaxial connector pin assignments shall be such that twisted shielded wire pin spacing facilitates attachment.

The connector shall not be shared with any other function.

Color-coded wire shall be used. The color for this wire shall be blue for positive (+) and white for minus (-).

7.3 *Connector Designators*

Each connector shall be labeled PJ1, PJ2, RJ1, or RJ2 where the “P/R” represents the prime or redundant instrument electronics and the “1/2” represents the prime or redundant 1553 bus to be attached.

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8 MISSION SCIENCE DATA TO RDRS

RDRs shall be assembled by ground processing and not by the instrument.

8.1 *Mission Data Content*

Science data packets shall contain all observed science data.

8.2 *Engineering (aka Auxiliary) RDR Data*

All auxiliary data required for inclusion with observed science data to comprise an RDR, but not including ephemeris data, shall be contained in a separate unique APID identified packet conforming to the engineering telemetry format.

8.3 *Spacecraft Ephemeris Data*

The spacecraft shall be responsible for ensuring the availability of ephemeris data for RDR assembly.

The instrument shall not put ephemeris data in any data packets.

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9 DEFINITIONS

9.1 Acronyms and Abbreviations

This section contains an alphabetical list of all of the abbreviations and acronyms used in this document.

Acronym	Definition
BC	Bus Controller
CCSDS	Consultative Committee for Space Data System
CDS	CCSDS Day Segmented Time Code
DRI	Data Ready Indicator
FSW	Flight Software
RT	Remote Terminal

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9.2 GLOSSARY

Byte:	The computer term for eight (8) digital data bits.
Data Set:	Multiple packets or packet segments during a single transfer.
Chunk:	A contiguous set of bits, not CCSDS formatted.
Epoch	The point in time, represented by a pre-specified indicator, where an event is to occur or data is to become effective.
1553 Message:	A 1553 message is comprised of up to thirty-two (32) each sixteen-bit (16) bit words or the maximum contents of one 1553 subaddress.
1553 Message Set:	The complete set of 1553 messages (subaddress contents) required for the transfer of 1 or more CCSDS packets and or CCSDS packet segments.
CCSDS octet:	The CCSDS term for eight (8) digital data bits also known as a byte.
CCSDS Packet:	A single CCSDS formatted chunk of data that may be complete unto itself or a part of the total Data Set to be transferred.
CCSDS Packet Set:	The total set of packet segments (always more than one) in a CCSDS formatted data transfer where the data is larger than a single packet permits.
CCSDS Packet Segment:	A CCSDS formatted chunk of data that requires other packet segments to compete the packet set.
Segmented	Data subdivided into multiple CCSDS packets, called CCSDS packet segments, thus comprising a CCSDS packet set.
Packet Segment	A single packet part of a larger CCSDS packet set.
Tuple:	A tuple is an ordered set of arbitrary length.
Word:	The computer term for sixteen (16) digital data bits or two (2) bytes or two (2) CCSDS octets.
Network Byte Order:	The order in which the bytes of a word are transmitted. For a 32-bit word; O1, O2, O3, O4, where O1 is the most significant CCSDS octet, O1 is transmitted first, O2 next, then O3, and finally O4. The same applies for any modulo 8-bit tuple.
Near Simultaneous	Near simultaneous means that multiple things occur in-time within a period shorter than the execution time of any of the individual items. Where there is a single serial port it might refer to having a second packet set input begin before the first has completed execution. It may also mean that multiple input APIDs packet sets may arrive together with individual packet segments arriving randomly related to the APIDs until all packet sets are received.

Deleted: File: A set of inter-related data stored, processed or communicated as a single unit.

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10 APPENDIX A, APID INITIAL ASSIGNMENTS

The following table defines the initial APID allocation range for each instrument. The content of each APID listed is only a sample. The final assignment for each data type shall be documented in the UIID. The range allocated for telemetry data is intended for housekeeping packets, LEO&A packets, telemetry monitor packets, and dwell packets. The range allocated for mission data is intended for science packets, engineering packets, calibration packets, memory dump packets, diagnostic packets, and test packets. If an instrument requires additional APIDs, this shall be negotiated with the SSPR contractor. Additional APID will be assigned from available spares. The block of spares allocated are not guaranteed to be contiguous with the existing allocation. The Ground Command APID shall be fixed and will not change. All other APIDs at the discretion of the SSPR contractor can be reprogrammed to accommodate the mission.

APID (Hex)			APID (Dec)			No. Ids	Packet Description	Spacecraft/ Instrument	
0	-	6	0	-	6	7	Telemetry	Spacecraft	
7			7			1	Ground Command	Spacecraft	
8			8			1	Spacecraft Command	Spacecraft	
9			9			1	Ground Memory Upload	Spacecraft	
A			10			1	Spacecraft Memory Upload	Spacecraft	
B	-	1F	11	-	31	21	Spare	Spacecraft	
20	-	87	32	-	135	104	Not used	Not used	
88	-	8F	136	-	143	8	Spare	ERBS	
90	-	96	144	-	150	7	Telemetry	ERBS	
97			151			1	Ground Command	ERBS	
98			152			1	Spacecraft Command	ERBS	
99			153			1	Ground Memory Upload	ERBS	
9A			154			1	Spacecraft Memory Upload	ERBS	

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APID (Hex)			APID (Dec)			No. Ids	Packet Description	Spacecraft/ Instrument	
9B	-	9F	155	-	159	5	Spare	ERBS	
A0	-	A7	160	-	167	8	Mission	ERBS	
A8	-	1FF	168	-	511	344	Not used	Not used	
200	-	206	512	-	518	7	Telemetry	ATMS	
207			519			1	Ground Command	ATMS	
208			520			1	Spacecraft Command	ATMS	
209			521			1	Ground Memory Upload	ATMS	
20A			522			1	Spacecraft Memory Upload	ATMS	
20B	-	20F	523	-	527	5	Spare	ATMS	
210	-	21F	528	-	543	16	Science – tbd	ATMS	
220	-	226	544	-	550	7	Telemetry	OMPS	
227			551			1	Ground Command	OMPS	
228			552			1	Spacecraft Command	OMPS	
229			553			1	Ground Memory Upload	OMPS	
22A			554			1	Spacecraft Memory Upload	OMPS	
22B	-	22F	555	-	559	5	Spare	OMPS	
230	-	23F	560	-	575	16	Science – tbd	OMPS	
240	-	246	576	-	582	7	Telemetry	GPSOS	

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APID (Hex)	APID (Dec)	No. Ids	Packet Description	Spacecraft/ Instrument	
247	583	1	Ground Command	GPSOS	
248	584	1	Spacecraft Command	GPSOS	
249	585	1	Ground Memory Upload	GPSOS	
24A	586	1	Spacecraft Memory Upload	GPSOS	
24B - 24F	587 - 591	5	Spare	GPSOS	
250 - 25F	592 - 607	16	Science – tbd	GPSOS	
260 - 266	608 - 614	7	Telemetry	TSIS	
267	615	1	Ground Command	TSIS	
268	616	1	Spacecraft Command	TSIS	
269	617	1	Ground Memory Upload	TSIS	
26A	618	1	Spacecraft Memory Upload	TSIS	
26B - 26F	619 - 623	5	Spare	TSIS	
270 - 27F	624 - 639	16	Science – tbd	TSIS	
280 - 286	640 - 646	7	Telemetry	Altimeter	
287	647	1	Ground Command	Altimeter	
288	648	1	Spacecraft Command	Altimeter	
289	649	1	Ground Memory Upload	Altimeter	
28A	650	1	Spacecraft Memory Upload	Altimeter	
28B - 28F	651 - 655	5	Spare	Altimeter	
290 - 29F	656 - 671	16	Science – tbd	Altimeter	
2A0 - 2A6	672 - 678	7	Telemetry	ADCS	

Comment: This table is as it was and is TBR until such time as we can work it.

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APID (Hex)	APID (Dec)	No. Ids	Packet Description	Spacecraft/ Instrument	
2A7	679	1	Ground Command	ADCS	
2A8	680	1	Spacecraft Command	ADCS	
2A9	681	1	Ground Memory Upload	ADCS	
2AA	682	1	Spacecraft Memory Upload	ADCS	
2AB - 2AF	683 - 687	5	Spare	ADCS	
2B0 - 2BF	688 - 703	16	Science – tbd	ADCS	
2C0 - 2C6	704 - 710	7	Telemetry	SARR	
2C7	711	1	Ground Command	SARR	
2C8	712	1	Spacecraft Command	SARR	
2C9	713	1	Ground Memory Upload	SARR	
2CA	714	1	Spacecraft Memory Upload	SARR	
2CB - 2CF	715 - 719	5	Spare	SARR	
2D0 - 2DF	720 - 735	16	Spare	SARR	
2E0 - 2E6	736 - 742	7	Telemetry	SARP	
2E7	743	1	Ground Command	SARP	
2E8	744	1	Spacecraft Command	SARP	
2E9	745	1	Ground Memory Upload	SARP	
2EA	746	1	Spacecraft Memory Upload	SARP	

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APID (Hex)			APID (Dec)			No. Ids	Packet Description	Spacecraft/ Instrument	
2EB	-	2EF	747	-	751	5	Spare	SARP	
2F0	-	2FF	752	-	767	16	Spare	SARP	
300	-	306	768	-	774	7	Telemetry	VIIRS	
307			775			1	Ground Command	VIIRS	
308			776			1	Spacecraft Command	VIIRS	
309			777			1	Ground Memory Upload	VIIRS	
30A			778			1	Spacecraft Memory Upload	VIIRS	
30B	-	30C	779	-	780	2	Spare	VIIRS	
30D	-	321	781	-	801	21	Science – tbd	VIIRS LRD	
322	-	337	802	-	823	22	Science – tbd	VIIRS HRD	
338	-	37F	824	-	895	72	Spare	VIIRS	
380	-	386	896	-	902	7	Telemetry	CMIS	
387			903			1	Ground Command	CMIS	
388			904			1	Spacecraft Command	CMIS	
389			905			1	Ground Memory Upload	CMIS	
38A			906			1	Spacecraft Memory Upload	CMIS	
38B	-	38C	907	-	908	2	Telemetry Monitored Packet	CMIS	
38D	-	39F	909	-	927	19	Science - tbd	CMIS LRD	
3A0	-	3B3	928	-	947	20	Science - tbd	CMIS HRD	
3B4	-	3FF	948	-	1023	76	Spare	CMIS	
400	-	406	1024	-	1030	7	Telemetry	SESS	

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Deleted: … ... [112]

Deleted: 30C ... [113]

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Deleted: … ... [114]

Deleted: 381 ... [115]

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APID (Hex)	APID (Dec)	No. Ids	Packet Description	Spacecraft/ Instrument
407	1031	1	Ground Command	SESS
408	1032	1	Spacecraft Command	SESS
409	1033	1	Ground Memory Upload	SESS
40A	1034	1	Spacecraft Memory Upload	SESS
40B - 40F	1035 - 1039	5	Spare	SESS
410 - 41F	1040 - 1055	16	Science - tbd	SESS
420 - 4BF	1056 - 1215	160	Not used	
4C0 - 4C6	1216 - 1222	7	Telemetry	APS
4C7	1223	1	Ground Command	APS
4C8	1224	1	Spacecraft Command	APS
4C9	1225	1	Ground Memory Upload	APS
4CA	1226	1	Spacecraft Memory Upload	APS
4CB - 4CF	1227 - 1231	5	Spare	APS
4D0 - 4DF	1232 - 1247	16	Science - tbd	APS
4E0 - 4E6	1248 - 1254	7	Telemetry	P3I
4E7	1255	1	Ground Command	P3I
4E8	1256	1	Spacecraft Command	P3I
4E9	1257	1	Ground Memory Upload	P3I
4EA	1258	1	Spacecraft Memory Upload	P3I
4EB - 4EF	1259 - 1263	5	Spare	P3I
4F0 - 4FF	1264 - 1279	16	Science - tbd	P3I
500 - 506	1280 - 1286	7	Telemetry	CrIS

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APID (Hex)	APID (Dec)	No. Ids	Packet Description	Spacecraft/ Instrument	
507	1287	1	Ground Command	CrIS	
508	1288	1	Spacecraft Command	CrIS	
509	1289	1	Ground Memory Upload	CrIS	
50A	1290	1	Spacecraft Memory Upload	CrIS	
50B - 50F	1291 - 1295	5	Spare	CrIS	
510 - 51F	1296 - 1311	16	Science - tbd	CrIS	
520 - 526	1312 - 1318	7	Telemetry	Special Sensor	
527	1319	1	Ground Command	Special Sensor	
528	1320	1	Spacecraft Command	Special Sensor	
529	1321	1	Ground Memory Upload	Special Sensor	
52A	1322	1	Spacecraft Memory Upload	Special Sensor	
52B - 52F	1323 - 1327	5	Spare	Special Sensor	
530 - 53F	1328 - 1343	16	Science - tbd	Special Sensor	
540 - 7EF	1344 - 2031	688	Not used/available	Not used	

Comment: This table is as it was and is TBR until such time as we can work it.

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APID (Hex)			APID (Dec)			No. Ids	Packet Description	Spacecraft/ Instrument	
7F0	-	7FE	2032	-	2046	15	Reserved	CCSDS Reserved	
7FF			2047			1	Fill Packet	All	

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Instrument packet sizes shall include all packet instrument contents.

6.5.2.2Telecomand Maximum Rates

Maximum telecommand rates shall be limited by the uplink rate, instrument operational constraints and the load requirements of the instrument.

All telecommand and memory load data rate or other operational constraints shall be documented in the UIID

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Spacecraft

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Spacecraft

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Calibration Packet

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Page 50: [130] Comment **Fredric S. Spandorf**

This table is as it was and is TBR until such time as we can work it.

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Telemetry Monitored Packet

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Memory Dump

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